RESEARCH DEPARTMENT

Airborne sound insulation requirements in studio centres

RESEARCH REPORT No. PH-21

UDC 534.861.1

1968/35

THE BRITISH BROADCASTING CORPORATION

ENGINEERING DIVISION

RESEARCH DEPARTMENT

AIRBORNE SOUND INSULATION REQUIREMENTS IN STUDIO CENTRES

Research Report No. PH-21
UDC 534.861.1 1968/35

It uses SI units in accordance with B.S. document PD 5686.

T.J.B. Smith, B.Sc., Ph.D., A.Inst.P.
C.L.S. Gilford, M.Sc., Ph.D., F.Inst.P., C.Eng., M.I.E.E.

Head of Research and Development

Research Report No. PH-21

AIRBORNE SOUND INSULATION REQUIREMENTS IN STUDIO CENTRES

August 1968

Research Report No. PH-21
UDC 534.861.1 1968/35

AIRBORNE SOUND INSULATION REQUIREMENTS IN STUDIO CENTRES

SUMMARY

This report assembles data on the sound power levels of various sources of interference, including studios and other technical areas, and on the permissible levels of noise in all parts of a studio centre. From these data, curves showing the required attenuation between sound sources and all types of broadcasting area are derived. As the shapes of the curves thus obtained do not in general agree with those realised by normal building practice, other curves are also drawn corresponding more closely in form with single- or double-layer partitions which provide equal or greater level reductions at all frequencies. The results are summarized in a design chart.

1. INTRODUCTION

The permissible levels of background noise in sound-broadcasting and television studios, control rooms and other technical areas have been specified in a previous report[1]. To ensure that these levels are not exceeded it is necessary to consider the sources of sound in all adjacent areas and to provide partitions having adequate sound reduction indices at all frequencies. A partition is usually a wall pierced with observation windows, doors and sound-lobbies, and is flanked by other walls and by ceilings and floors; in this report all references to a partition will therefore be taken to include all these parallel paths of transmission. The cases considered here are those in which the source of interference (e.g. musical instrument, loudspeaker, etc.) does not excite the structure of the area under consideration solely by transmission through solid materials.

A partition separating two areas must satisfy the following requirements:-

1. It must reduce the level of interfering sound so that when this is combined with the sound generated by unwanted internal sources, it does not result in a level higher than the accepted criterion. (Generally, transmission of sound in one direction is of more consequence than in the other and all designs must take into consideration the direction of worst potential interference.)
2. The partition should not be heavier or more complex than is necessary to provide adequate sound insulation. Large factors of safety in sound insulation are extremely expensive.
3. If the partition separates areas such as a studio and its cubicle, which are electro-acoustically coupled by a microphone, an amplifier and a monitoring loudspeaker, the sound reduction must be great enough at all frequencies to prevent any appreciable modification to the acoustic characteristics of the studio due to feed-back through the partition from the loudspeaker to the microphone.

The sound-level difference to be created by a partition between two areas will be determined by the level of background noise permitted on the 'receiving' side and the sound level on the other. However, the sound reduction index of the partition (i.e. its inherent attenuation) required to achieve this sound-level difference will depend also on the area of the partition and on the size of and absorption in the receiving room. For instance, if the partition is of small area and the receiving room has a large volume, and is extensively treated with sound absorbers, the partition need not have so high a sound reduction index as if it were the largest wall of a very reverberant receiving room.

The sound reduction index of a partition of area A required to attenuate by D dB the sound level in passing from a source room to a receiving room which has surface area S and mean absorption coefficient α is given by[2]

$$D + 10\ \log_{10} A(1-\alpha)/(S\alpha),\ \text{dB}$$

The correcting term $10\ \log_{10} A(1-\alpha)/(S\alpha)$, has negative values for all normal studio applications, amounting to about −8 dB in favourable cases.

The correction, for similarly shaped studios, depends mainly on the mean absorption coefficient of the surfaces and on the size of the wall through which the interference is transmitted. Typical corrections, for use in cost-magnitude calculations are:-

for music studios	−2 to −6 dB;
for talks or drama studios	−4 to −7 dB;
for television studios	−5 to −8 dB;

the smaller correction being for transmission through the whole of a long wall, and the larger for transmission through a short wall or only part of a wall.

2. CALCULATION OF REQUIRED SOUND LEVEL REDUCTION

2.1. Permissible Background Noise

Fig. 1 shows, from Reference (1), the three criterion curves adopted by the BBC to specify the maximum allowable background noise in studios and control cubicles. They will be referred to in this report as criterion A, B and C. Criterion A applies to radio light-entertainment studios, criterion C to radio drama studios, criterion B to all others. These criteria have been derived from subjective assessments over a number of years and may be regarded as the optimum combination of satisfaction and cost. More stringent requirements have been recommended by other broadcasting authorities[1] but no subjectively significant improvement results from reducing the background noise below the levels shown in the curves. (An exception might be made for a few types of programme, such as clavichord music, which requires an exceedingly quiet background; but for these, special arrangements can be made.)

2.2. General Method of Calculation

The first step in the calculation of the required sound-reduction characteristics of a partition is to determine the sound pressure level spectrum of the source and to subtract, at each frequency, the sound pressure level given by the criterion curve appropriate to the receiving area. From this we obtain an ideal curve for the level difference (in dB) plotted against frequency to be introduced by the intervening partition.

However, it is not possible to design a real partition with any exactly specified curve of attenuation against frequency and the next stage in the calculation is to compare the required curve with the sound reduction characteristics obtained from practical structures. For example, that of a single massive but limp* wall has a mean positive slope of approximately 5 dB per octave and for many applications represents a practical solution. But if a mean sound-level reduction exceeding 50 – 60 dB is required, (calculated at one-third octave intervals within the standard range from 100 Hz to 3,200 Hz) the mass of such a wall is excessive and a multiple form of construction must be used, whose attenuation characteristic necessarily has a higher slope. The required curve must then be matched to one with a slope of, say, 10 dB per octave, and the requirements of low-frequency insulation usually determine the total mass of wall which will be needed. A factor which must be considered in this connection is the minimum insulation required to prevent howl-round; this minimum may be set in practice by the stiffness of the partition, which

* i.e. a wall of which the stiffness reactance may be neglected in comparison with the mass reactance in the frequency range considered. Common masonary structures such as brick walls fulfil this condition over the mid-frequency range but their characteristics normally show a minimum at lower frequencies below which there is a plateau or even an increase of sound-reduction index with reduction of frequency.

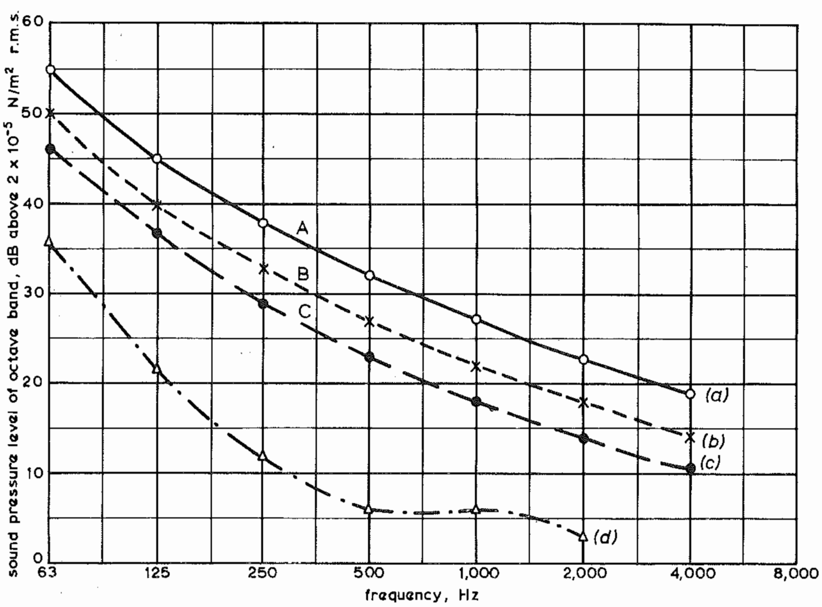


Fig. 1 - Background noise criteria for studios

(*a*) Curve A for light entertainment radio studio
(*b*) Curve B for all television studios and for radio studios other than those covered by (*a*) or (*c*)
(*c*) Curve C for radio drama studios
(*d*) Threshold of hearing for narrow-band noise in a diffuse field

controls the insulation at frequencies below the lowest resonance, and the maximum at high frequencies is determined mainly by the leakage paths through door seals, cable ways etc. The practical sound-reduction characteristic may thus be specified by horizontal lines representing respectively the minimum low-frequency reduction and the limiting insulation at high frequencies, joined by a line of the appropriate slope. Four numbers are required to specify the shape of this figure, preferably the co-ordinates of the junctions between the sloping line and the horizontal portions at the ends. In this report the recommended sound reduction at 500 Hz is also quoted as a round representation of the mean value, as defined above.

The way in which this general procedure is applied will be seen from the Appendices A1 to A5.2 of the report. The curves of required and recommended sound reduction in Figs. 3 – 12 refer, unless otherwise stated, to areas requiring criterion B background noise limitation.

Fig. 2 shows recommended parameters, derived in this manner, for the sound reduction required between each type of studio-centre and various forms of interfering source.

The diagram is divided into boxes, each of which is subdivided into five smaller boxes as shown in inset (*a*). The numbers in the boxes are the parameters of the recommended partition sound-reduction characteristics shown in inset (*b*).

To find the parameters for a partition between any two areas, read from the box which lies at the intersection of a row leading from the description of one area and the column descending from the description of the other area.

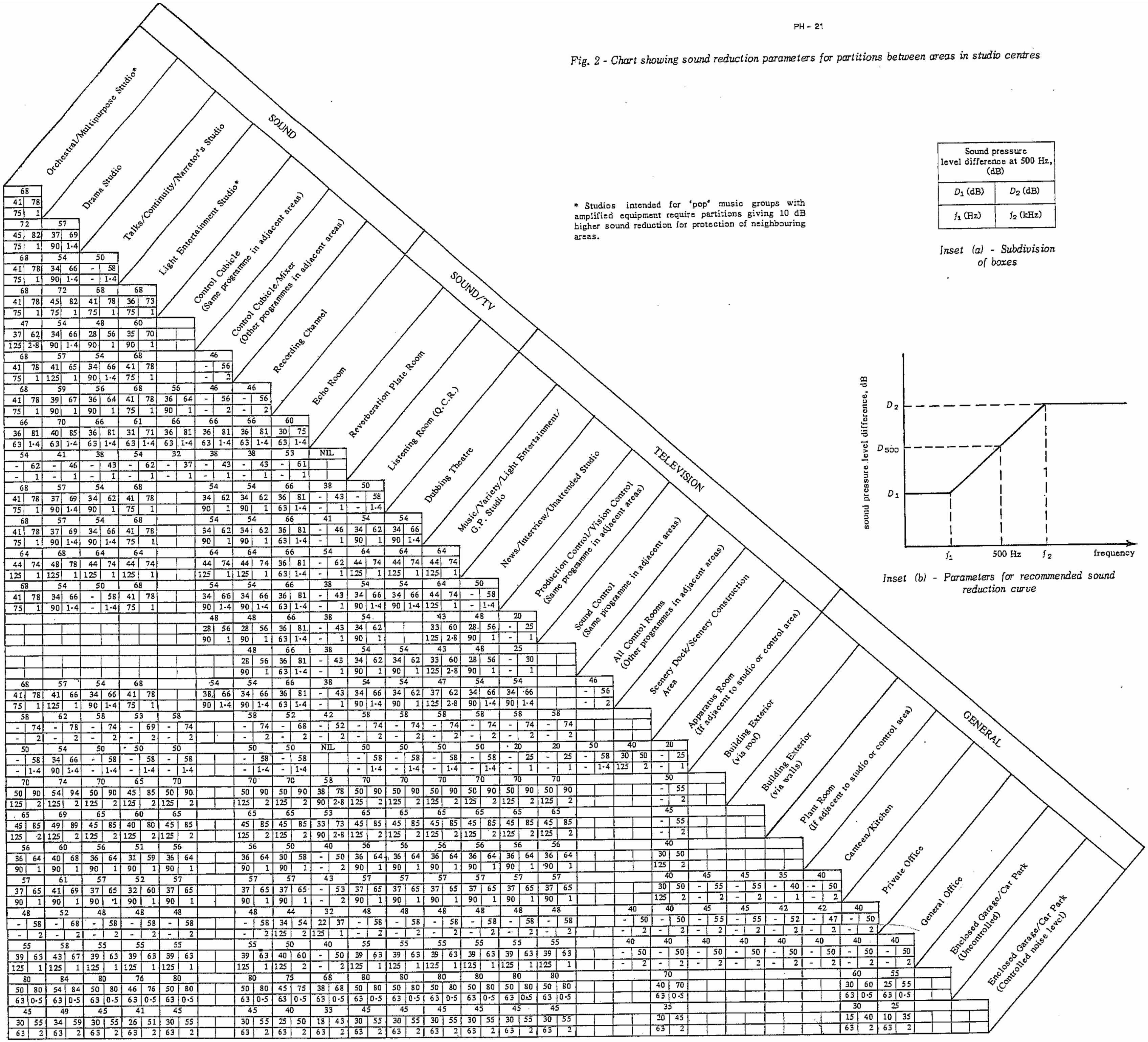
3. CONCLUSIONS AND RECOMMENDATIONS

This report shows a logical way of determining the required sound insulation characteristics of the partition separating any studio or other operational area from neighbouring areas.

The recommendations are contained in Fig. 2 which gives five parameters to define the characteristics of the partition. This is the first comprehensive guide which has been made available to designers.

The majority of the figures have been checked against data derived from previous experience and are in good agreement.

Fig. 2 - Chart showing sound reduction parameters for partitions between areas in studio centres



* Studios intended for 'pop' music groups with amplified equipment require partitions giving 10 dB higher sound reduction for protection of neighbouring areas.

Sound pressure level difference at 500 Hz, (dB)	
D_1 (dB)	D_2 (dB)
f_1 (Hz)	f_2 (kHz)

Inset (a) - Subdivision of boxes

Inset (b) - Parameters for recommended sound reduction curve

APPENDIX

Application to Specific Areas

A.1. Sound Studios

A.1.1. Orchestral and Multi-purpose Studios

This class includes the largest sound studios, with volumes up to 7000m^3 or more and mid-frequency reverberation times up to two seconds. A studio of this class requires a background noise-level less than criterion B (Fig. 1), and, when being used by a symphony orchestra or a 'pop group' using electronically amplified instruments, becomes a source of interfering sound for other studios which is the equal of a low-flying jet aircraft.

Table 1 lists mean sound power levels in octave bands for 75-piece and 15-piece orchestras, from data given by Beranek[3]. Peak levels are stated by him to be generally up to 15 dB higher.

From these data, typical sound pressure levels at the studio walls can be computed, using known formulae[4] to combine the direct and reverberant sound fields.

The sound pressure level at a distance r from a source is equal to:

$$L_p = L_W + 10 \log_{10} \left\{ \frac{1}{4\pi r^2} + \frac{4(1-\bar{\alpha})}{S\bar{\alpha}} \right\} + 0{\cdot}2 \text{ dB}$$

where L_p = Sound pressure level relative to 2×10^{-5} N/m^2. (dBp)*

* The notation dBp is in current use in the BBC to denote 'dB relative to 10^{-5} N/m^2'. For plane waves in air this reference level is approximately equivalent to 1 picowatt/m^2.

TABLE 1

Mean Sound Power Levels of Orchestras

Mean Sound Power Level ref. 10^{-12}W for	Centre Frequencies of Octave Bands, Hz 63	125	250	500	1k	2k	4k	8k
75-piece Orchestra	86	90	94	94	92	91	88	82
15-piece Orchestra	76	80	84	83	82	81	78	72

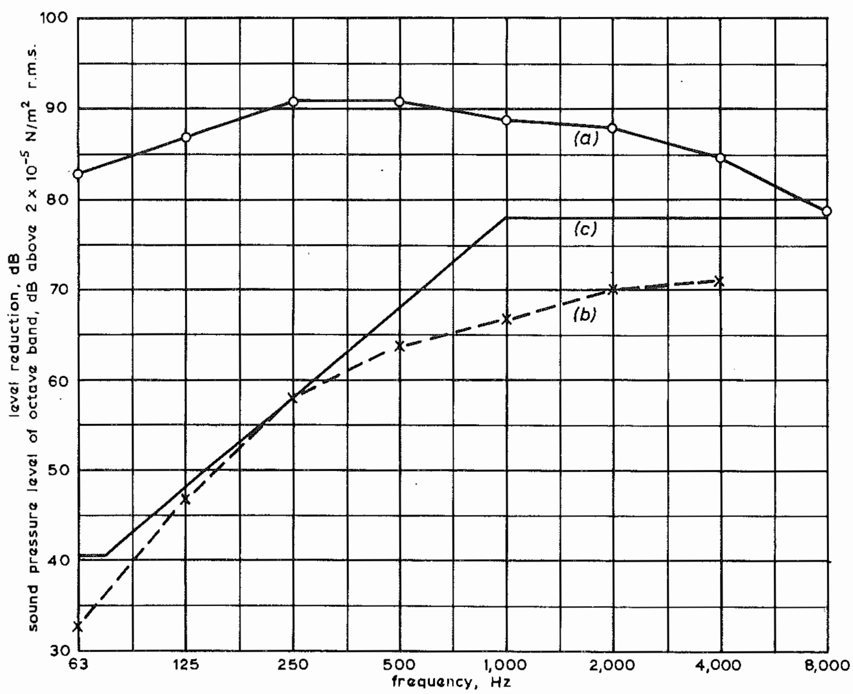


Fig. 3 - Sound reduction requirements — Music Studios

(*a*) Maximum sound pressure levels
(*b*) Required reduction to adjacent studio requiring criterion B
(*c*) Proposed sound reduction curve from drama studio

L_W = Sound power level relative to 10^{-12}W.
S = Total surface area of room (m^2).
$\bar{\alpha}$ = Average absorption coefficient of room boundaries.
[$S\bar{\alpha}/(1 - \bar{\alpha})$ is generally called the room constant and denoted by R]

Curve (a) of Fig. 3 shows maximum values of L_p for a 75-piece orchestra in a medium-sized orchestral studio (V = 3500 m^3, R = 400 m^2 and r = 5 m, so that $L_p = L_W$ − 18·6 dB). For the same orchestra in a small studio, the levels will be greater, but only slightly so. A 15-piece orchestra in a typical small music studio of 570 m^3 volume will give maximum values reduced by about 5 dB with respect to those shown in Fig. 3, curve (a), which may therefore be taken as representative of the highest sound levels at a wall of a music studio.

Curve (b) of Fig. 3 shows, by subtraction from curve (a), the sound level reduction required to attain criterion B of Fig. 1.

A single-leaf partition adequate to provide the sound reduction shown in curve (b) would be represented by a straight line of 5 dB/octave slope coinciding with curve (b) at 500 Hz and having a mean value of 65 dB when averaged at one-third-octave intervals between 100 and 3,200 Hz. (This is the lowest line with this slope which does not go below curve (b) at any frequency.) Such a partition would be of impracticably great mass and therefore it is assumed that a multi-leaf wall would be used. Curve (c) of Fig. 3 shows a characteristic which would be suitable and could be met by an economical two-leaf form of construction. The centre portion of the characteristic has a slope of 10 dB/octave. At low frequencies it should not fall below 40 dB, while the upper limit of 78 dB is adequate at all frequencies.

This curve is proposed, therefore, as the required insulation characteristic between two music studios, or more generally as the characteristic of a partition required to protect from the sound of a music studio any studio to which background noise criterion B applies.

The requirements for the partition between the studio and its control cubicle are less stringent than that represented by curve (c) of Fig. 3 because slightly delayed sounds coming directly through the partition from the studio to the cubicle are masked by the identical sounds of higher level from the monitoring loudspeaker and need not therefore be attenuated to more than about 20 dB below monitor-level to be imperceptible.[5] If monitoring were carried out at the actual level of the sound in the studio, 20 dB would therefore be an adequate mean sound reduction. However, monitoring peak levels are normally at least 10 dB lower than studio peak levels, so that the sound level reduction provided by the partition must be accordingly greater. In practice, 45–50 dB mean sound-level reduction is found to be sufficient between a music studio and its cubicle.

Since the monitoring levels during loud passages are well below studio levels, the studio sound will be unaffected by transmission of loudspeaker sound through the same partition.

A.1.2. Sound Drama Studios

A drama studio is never likely to be a serious source of sound interference with neighbouring studios; the loudest sound normally produced is that of loud speech and occasional effects such as gun shots. The development of quick-access tape recordings will soon make the use of such 'acoustic' effects largely unnecessary; the effects might still be played into the studio for the benefit of the actors, but only at a comparatively low level.

The power levels of loud dramatic male speech in octave bands are quoted from Beranek[2] in Table 2.

Curve (a) of Fig. 4 is the sound pressure level at the studio wall from an actor in a typical drama studio (volume 280 m^3, reverberation time 0·6 s), calculated as a function of frequency according to the methods of the previous section. Peak power levels 10 dB above those in Table 2 are assumed, and the distance from the nearest wall is taken as 1·5 m, giving a correction factor of −10·5 dB.

Curve (b) of Fig. 4 is the curve describing the required insulation of a drama studio, adjacent to this studio, to attain criterion C. This would be met in practice by the idealized curve (c). A neighbouring studio in which criterion B refers would require 4 dB less protection but, if the adjacent studio is a music studio, the partition should be designed to provide 4 dB more attenuation than that described by curve (c) in order to avoid interference in the drama studio from the music studio. Here, as in all similar cases, the partition should satisfy the higher requirement.

A.1.3. Talks and Discussion Studios

Speech in talks and discussion studios does not normally reach the levels of Table 2. Table 3 represents the mean sound-pressure levels to be expected; it is derived from power-level data by Beranek[3], from pressure levels published by the British Standards Institution[6] and confirmatory measurements in Research Department; peak levels are approximately 10 dB higher.

TABLE 2

Mean Sound Power Levels of Declamatory Male Speech

Centre frequencies of octave bands, Hz	63	125	250	500	1k	2k	4k	8k
Mean sound power level, dB rel. 10^{-12}W	69	74	77	80	80	73	64	52

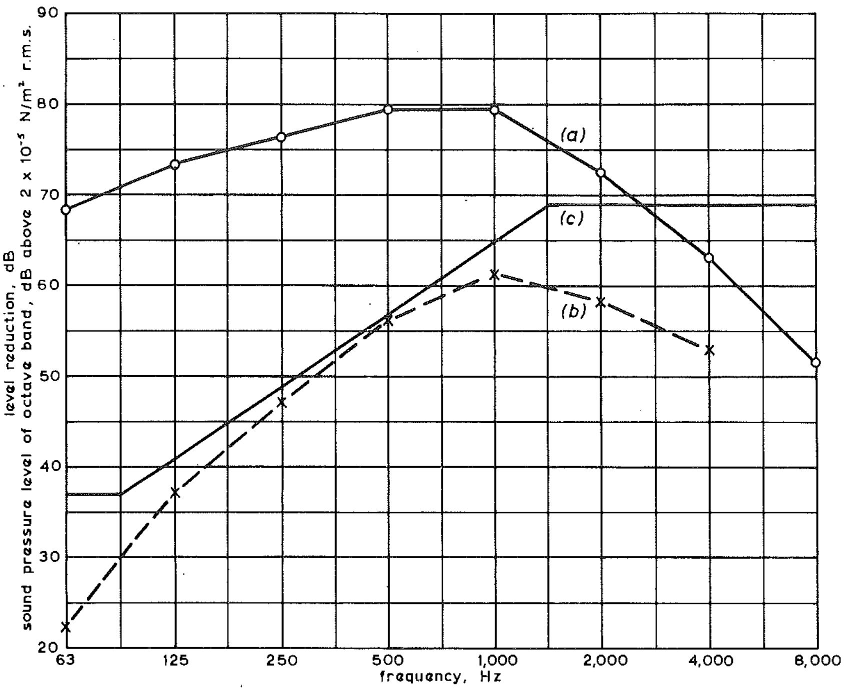


Fig. 4 - Sound reduction requirements — Radio Drama Studios

(*a*) Maximum sound pressure levels
(*b*) Required reduction to adjacent drama studio
(*c*) Recommended reduction to drama studio

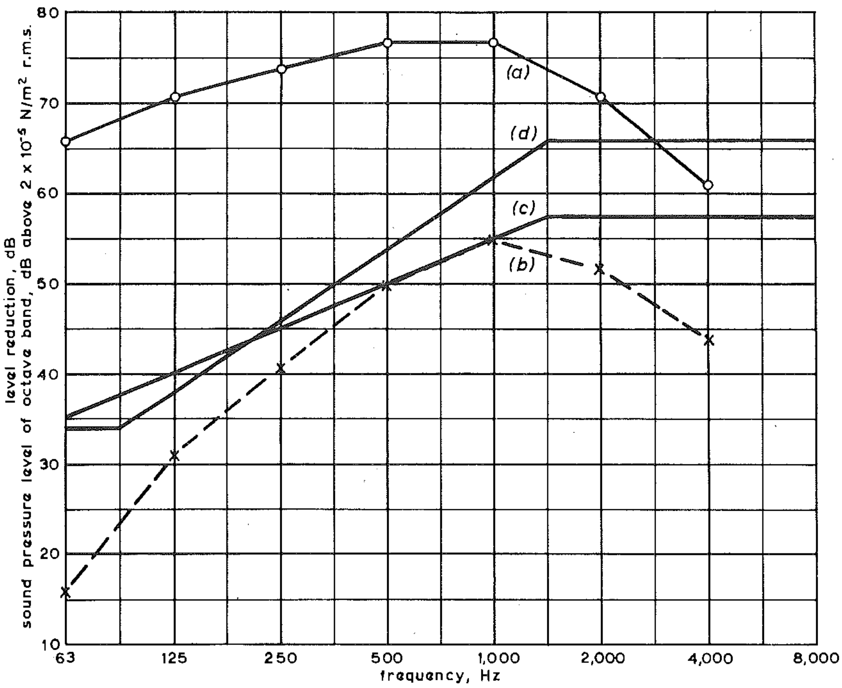


Fig. 5 - Sound reduction requirements — Talks Studios

(*a*) Maximum sound pressure levels
(*b*) Required reduction to adjacent talks studio
(*c*) Proposed minimum transmission loss from adjacent talks studio
(*d*) Proposed minimum transmission loss from adjacent drama studio

Curve (*a*) of Fig. 5 shows, as a function of frequency, the peak pressure levels, which are assumed to be 10 dB above the mean levels in Table 3, and curve (*b*) gives the required insulation to attain criterion B in the neighbouring studio.

Curve (*c*) assumes a single-leaf construction (e.g. a 230 mm (9 in.) brick wall) with a gradient of 5 dB per octave, and is very similar to the recommendation, based entirely on operational experience, already in use in the BBC[1].

TABLE 3

Mean Sound Pressure Levels at 1 m Distance due to Didactic or Conversational Speech

Centre frequencies of octave bands, Hz	63	125	250	500	1k	2k	4k
Mean sound pressure level, dBp	56	61	64	67	67	61	51

For an adjacent drama studio requiring criterion C an increase of 4 dB would be needed in the insulation and this would be more economically provided by a double-leaf construction with an idealized characteristic such as Fig. 5 curve (*d*). If reference is now made to Fig. 4 it will be noted that a drama studio should be protected from a talks studio by a partition giving 4 dB less insulation than curve (*d*) in Fig. 5. Hence, a slightly greater insulation is required to protect a talks studio from a drama studio than vice versa and design should be carried out accordingly.

A.1.4. Sound Control Rooms

Under this title are included all areas in which sound control, monitoring or recording takes place. All such rooms are of approximately the same size and reverberation time. The permissible background noise criteria are the same as those of the studios to which they are attached; as noise sources they will generally be intermediate between talks studios and music studios, because it is nomal practice to monitor speech at a higher level and music at a lower level than that of the sound in the studio. As mentioned in the introductory sections of this report, a lower limit must be placed on the sound level reduction between a cubicle and its associated studio to avoid howl-round. Cubicles monitoring the studio programme from recording machine replay heads will require about 6 dB greater reduction since the sound from the monitoring loudspeaker will be delayed by the time of transit between the recording and replay heads and will not be masked by the programme. The variety of conditions is thus so large that separate curves similar to those of Figs. 3 – 5 will not be shown. The recommended characteristics are shown as entries in Fig. 2

A.2. Echo Rooms and Reverberation Plate Rooms

A.2.1. Echo Rooms

The loudspeakers in echo rooms are normally operated near to maximum power output to ensure a good signal-to-noise ratio. They are thus potentially high-level noise sources but will tolerate higher background noise levels than studios.

The forward gain of an echo channel is normally about 10 dB[7] and therefore if the noise in the room does not exceed criterion C by more than 10 dB, the room will be suitable for all purposes. This will provide the basis of the design so far as external interfering noise is concerned.

Measurements of peak sound pressure levels in echo rooms are shown in Table 4

TABLE 4

Peak Sound Pressure Levels in Echo Rooms

Centre frequencies of octave bands, Hz	63	125	250	500	1k	2k
Peak octave band sound pressure levels, dBp	86	86	86	91	95	90

Fig. 6 shows these figures together with sound reduction curves required to attain criterion B in an adjacent area. Double-leaf walls will be required even between two adjacent echo rooms and for this reason they are normally located in remote parts of a studio centre with ample separation from other broadcasting areas.

A.2.2. Reverberation Plate Rooms

As stated by Kuhl[8] the inherent noise voltage at the output of a reverberation plate is equivalent to an ambient noise level of 50 to 55 phons outside the casing. This noise level is similar to that in a quiet office and therefore the plate may be kept in any quiet room provided that precautions are taken against contact with the casing. It should not be placed in a control room even if always used for the studio programme, since acoustical feed-back is likely to occur around 200 Hz. Ideally all the reverberation plates for a studio centre should be installed in a special room protected by 230 mm (9 in.) brick walls.

A.3. Television Studios

All television studios and associated areas have been assigned background criterion B. As sources of noise they are less important than are sound studios used for similar types of programme, because of their greatly increased absorption. The sound reduction parameters are summarised in Fig. 2. The control rooms require protection similar to that recommended for music studios, as described in Section A.1.1.

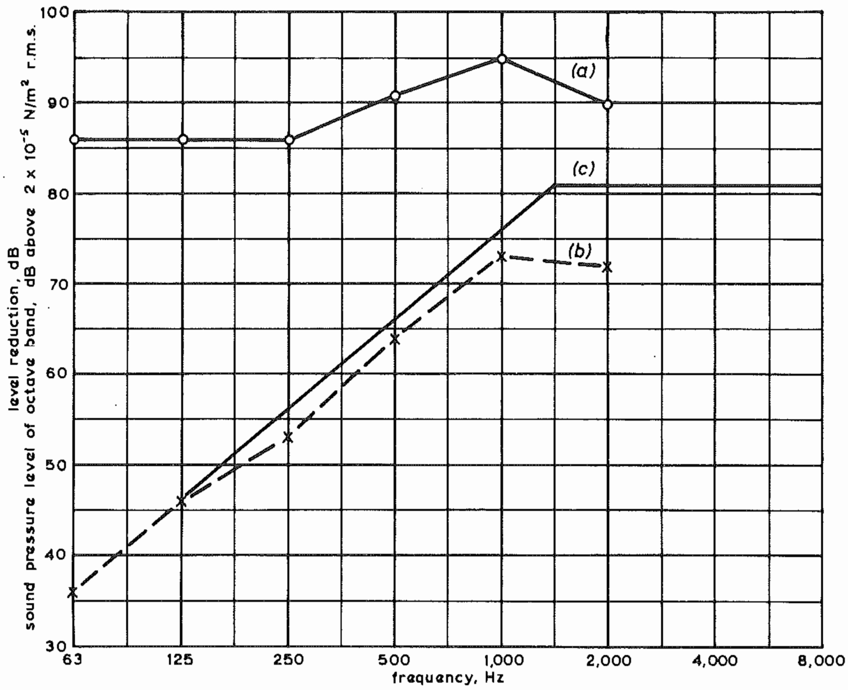


Fig. 6 - Sound reduction requirements — Echo Rooms

(*a*) Maximum sound pressure levels
(*b*) Required reduction to adjacent studio requiring criterion B
(*c*) Proposed sound reduction curve

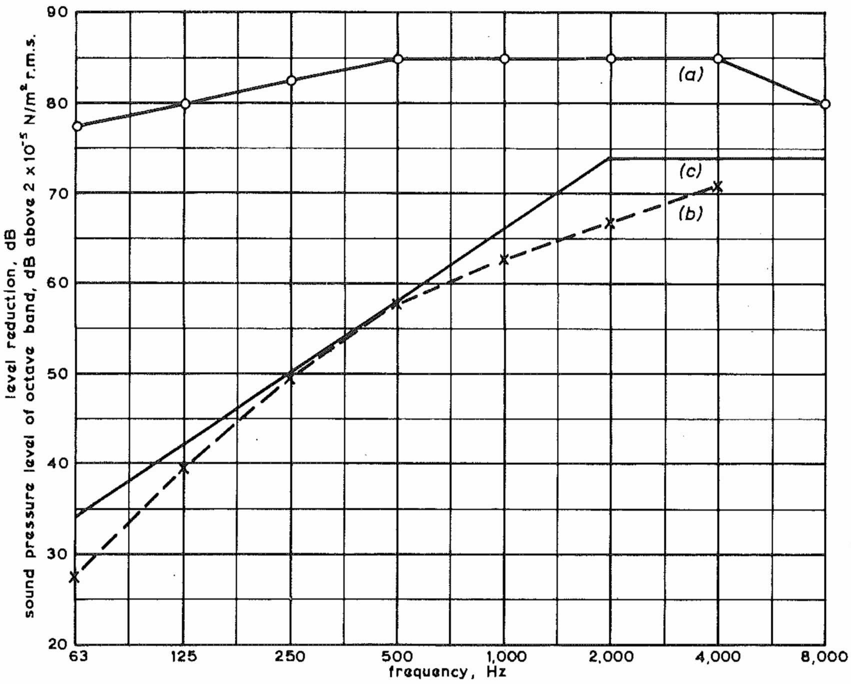


Fig. 7 - Sound reduction requirements — Scene Dock Construction Areas

(*a*) Maximum sound pressure levels
(*b*) Required reduction to television studio
(*c*) Proposed sound reduction curve

A.4. Construction and Service Areas

A.4.1. Scene Docks and Scenery Workshops

Scene docks are normally adjacent to television studios and constitute a source of noise associated with traffic and the handling of scenery. It may also be necessary to carry out scenery modifications in the dock or even to include the constructional workshop in the dock area. Fig. 7 curve (*a*) shows the peak spectrum levels of noise from woodworking machinery based on measurements in such installations by Research Department and others.[9] Curves (*b*) and (*c*) show required and proposed sound level reductions to a television studio.

A.4.2. Plant Rooms

Rooms containing ventilating, heating and air-conditioning plant are best located in a part of a studio centre well-separated acoustically from those parts directly concerned with broadcasting. Particular circumstances may make juxtaposition of a

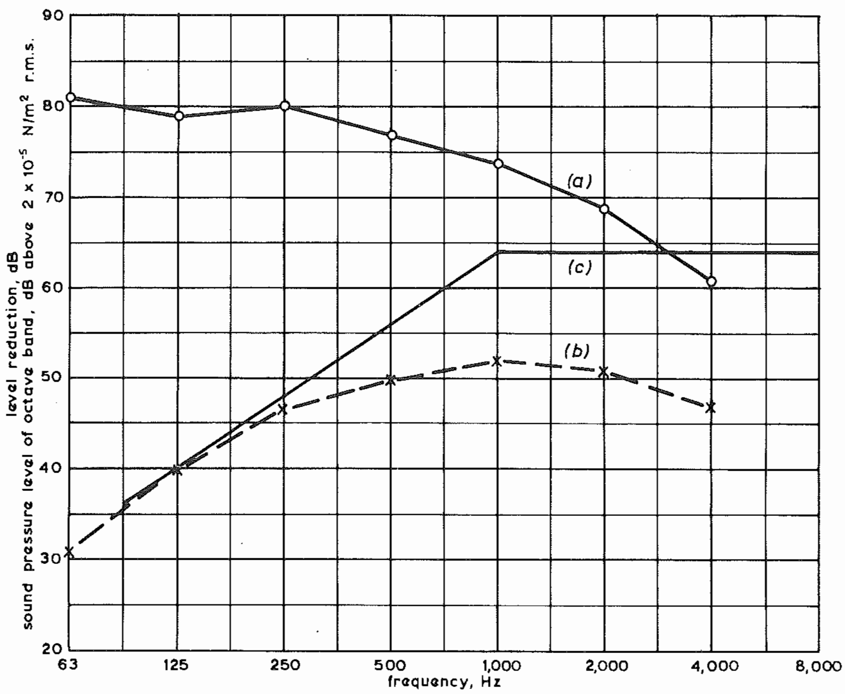


Fig. 8 - Sound reduction requirements – Plant Rooms

(*a*) Median values of plant room noise
(*b*) Required reduction for criterion B studio
(*c*) Proposed sound reduction curve

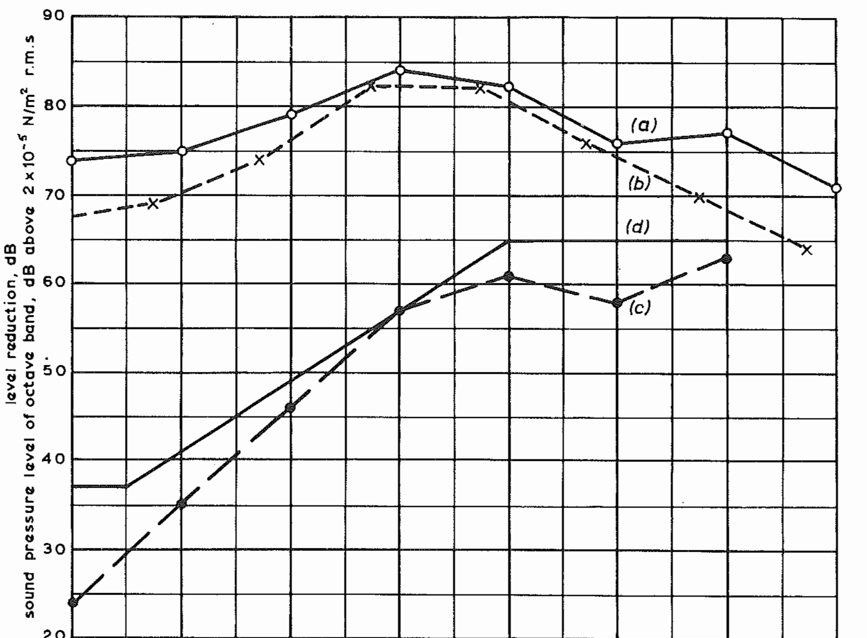


Fig. 9 - Sound reduction requirements – Canteens and Kitchens

(*a*) Maximum sound pressure levels (BBC measurements)
(*b*) Maximum sound pressure levels (from Reference 6)
(*c*) Required level reduction to a studio requiring criterion B
(*d*) Proposed sound reduction curve

plant room and a studio unavoidable, however, and Fig. 8 shows the design curves which must then be specified for the separating partitions. Curve (*a*) is based on the mean of several surveys quoted by Kibblewhite[10] for ventilation plant rooms, and on confirmatory measurements by Research Department at Television Centre. Curve (*c*) is a proposed insulation characteristic which will be adequate for almost all circumstances. Kibblewhite's surveys show that levels up to 6 dB higher than curve (*a*) can occur but, as these would cause excess noise in the lowest three octaves only, the effect would not be serious.

A.4.3. Restaurants and Kitchens

The noise level curves (*a*) and (*b*) of Fig. 9 are based on Research Department measurements in BBC canteens and British Standards Institution Data from Reference (6), corrected for peak values by the addition of 15 dB. Curves (*c*) and (*d*) are derived on the assumption of the higher noise level curve (*a*) and a neighbouring area to which criterion B would apply.

Food preparing machines and dropped utensils can be important sources of noise from kitchens, but the noise is largely propagated as structure-borne rather than airborne sound and is therefore not considered in this survey.

A.4.4. Garages and Car Parks

Fig. 10, curves (*a*) and (*b*) show the results of noise measurements in two underground car parks. Curve (*a*) was for the noisiest of several sports or large-capacity cars which gave octave-band levels over 90 dBp when driven fast. Approximately 90% of the cars, however, gave levels lower than curve (*b*). The required and recommended sound reduction curves for the noisy cars are curves (*c*) and (*d*), while those for the majority of cars are (*e*) and (*f*), assuming criterion B in both cases.

Curve (*d*) would be difficult to attain even taking into consideration the assumption that studios immediately above the car park would be floated on resilient mountings, whereas curve (*f*) would normally be realised without any special measures.

It is clear, then, that if studios are mounted directly over a car park, some control should be exercised over cars using the area. Noisy vehicles should be excluded either by supervision or by automatic means actuated by a sound-level meter situated on a covered rising slope near the entrance.

A.5. Offices

For the purposes of noise control, offices are usually classified as 'private offices' in which the background noise is low enough for uninterrupted thought and discussion, or 'general offices' containing many people with typewriters or teleprinters.

A.5.1. Private Offices

Curve (*a*) of Fig. 11 shows the background noise criterion proposed by Research Department for private offices as a result of surveys in 1964 and 1965. It lies very close to the rating curve NR40 of Kosten and van Os[11] recommended by the International Organization for Standardization for the same purpose.

Curve (*b*) of Fig. 11 is a mean of noise levels due to traffic, in 23 offices at Broadcasting House. Noise originating within the offices increased the divergence from curve (*a*) at high frequencies, giving curve (*c*) which was taken as a *de facto* curve for the office as a noise source. Peak levels were found in practice to be 15 dB higher. Curves (*d*) and (*e*) are the required and recommended sound reductions to protect a studio requiring criterion B from the office noise. In calculations for the protection of offices from other noise sources curve (*a*) is assumed to apply. The results are included in Fig. 2.

To protect a neighbouring private office only 33 dB mean insulation would appear to be necessary. There are no British Standard recommendations for this case, but other countries[12] generally require 40 dB. This figure is recommended in Fig. 2.

A.5.2. General Offices

General offices occupied by many people who may be using typewriters, teleprinters and tele-

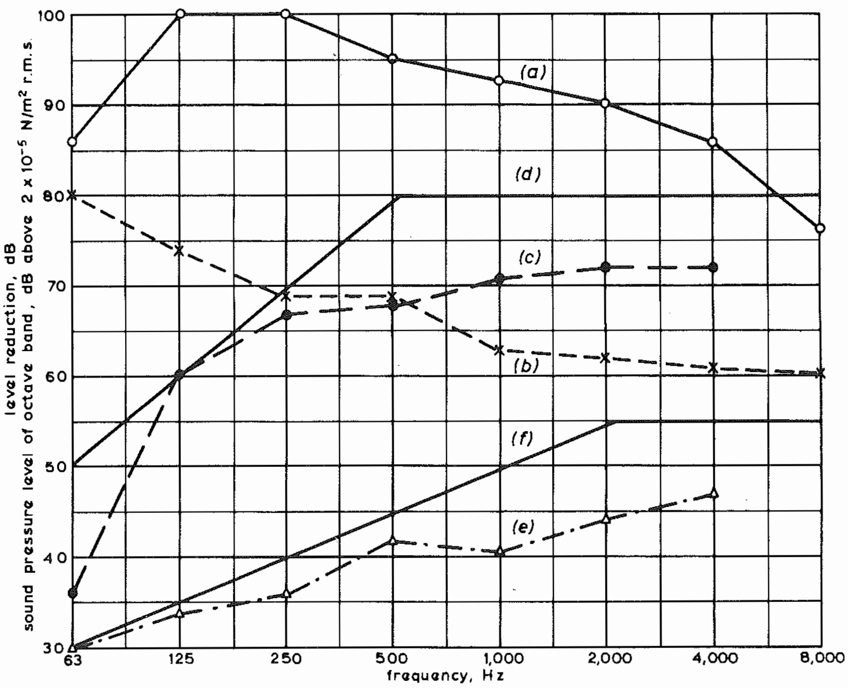


Fig. 10 - Sound reduction requirements — Closed Car Parks or Garages

(*a*) Maximum levels from sports car
(*b*) Maximum levels from lower 90% of vehicles
(*c*) Required reduction to criterion B (from curve (*a*))
(*d*) Recommended reduction, use restricted to normal vehicles
(*e*) Required reduction to criterion B (from curve (*b*))
(*f*) Recommended reduction - unrestricted use

phones normally maintain a higher level of internally generated noise than do private offices; a higher background due to external sources is therefore permissible. Fig. 12 curve (*a*) shows the highest values from a number of measurements in such offices in BBC premises. The spread of measurements over these was less than 10 dB at all frequencies.

Curve (*b*) is Noise Rating curve 55 recommended by the International Organization for Standardization for general offices; curves (*c*) and (*d*) are the required and proposed insulation curves for a studio requiring criterion B sited next to a general office allowing peaks of 15 dB above the mean level measurements shown by curve (*a*). A double-leaf partition is necessary.

A.6. Studio Roofs and Exterior Walls

All studio roof and wall insulation criteria are taken from a recent Research Department Report[13] which describes a study of present-day aircraft noise levels and possible future sonic booms, and their effects on broadcasting studios. It concludes that, at present, studios require an average roof insulation of at least 65 dB to provide adequate protection against aircraft noise, but that with the advent of supersonic airliners and the general

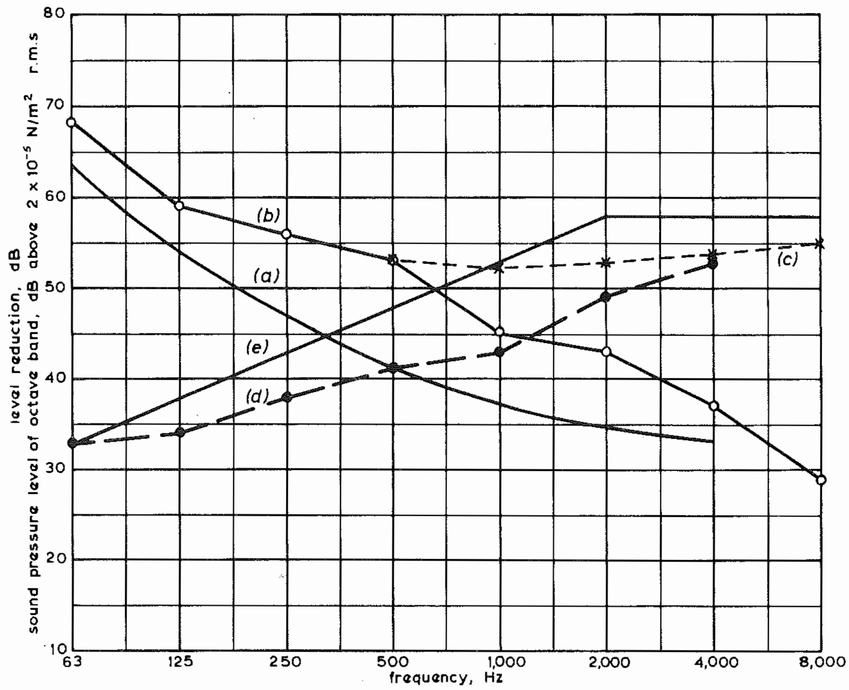


Fig. 11 - Sound reduction requirements — Private Offices

(*a*) Acceptable limit of background noise
(*b*) Typical noise levels due to traffic
(*c*) Internally-generated noise
(*d*) Reduction required for criterion B, allowing for peaks 15 dB above curves (*b*) or (*c*)
(*e*) Recommended reduction

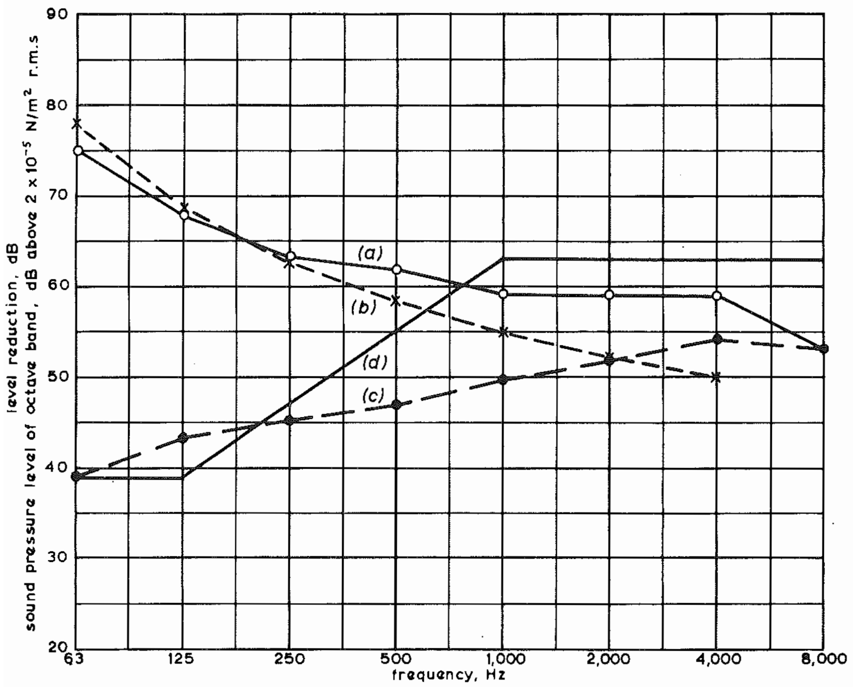


Fig. 12 - Sound reduction requirements — General Offices

(*a*) Internally-generated sound levels
(*b*) I.S.O. rating curve for offices
(*c*) Required reduction to criterion B, allowing for peaks 15 dB above curves (*a*) and (*b*)
(*d*) Recommended reduction

increase in air traffic density in the next few years an average roof insulation of 70 dB should be adopted for all new studios.

It has been found that studio walls can be built to meet a slightly lower insulation criterion and still give adequate protection against external noise. A reduction of 5 dB from the proposed roof insulation is suggested, an average of 60 dB being sufficient at present. This figure may need to be increased in the isolated instances (as, for example, the new Manchester Headquarters) where a studio centre is in close proximity to a motorway or similar source of high traffic-noise levels.

4. REFERENCES

1. Psychoacoustic criteria for background noise and sound insulation in broadcasting studios. BBC Research Department Report No. PH-5, Serial No. 1967/11.

2. British Standard 2750 : 1956. Recommendations for field and laboratory measurement of airborne and impact sound transmission in buildings, p. 6.

3. BERANEK, L.L. 1954. Acoustics. New York, McGraw-Hill, 1954, p. 338.

4. See for example, BERANEK Ibid, p. 321.

5. MUNCEY, R.W., NICKSON, A.F.B. *and* DUBOUT, P. 1952. The acceptability of speech and music with a single artificial echo. *Acustica*, 1953, **3**, 3, pp. 168 – 173.

6. British Standard Code of Practice CP3. 1960. Code of basic data for the design of buildings. Chap. 3 – Sound insulation and noise reduction.

7. BROWN, S. 1963. Acoustic design of broadcasting studios. *Jnl. Sound & Vibrn.*, 1964, **1**, 3, pp. 239 – 257.

8. KUHL, W. 1958. The acoustical and technological properties of the reverberation plate. *E.B.U. Rev.*, 1958, **49A**, pp. 8 – 14.

9. HARRIS, C.M. 1957. Handbook of noise control. New York, McGraw-Hill, 1957, Appendix 1.1.

10. KIBBLEWHITE, D. 1965. Noise levels in boiler houses and plant rooms. Heating and Ventilating Research Association Lab. Rep. No. 27, 1965.

11. KOSTEN, C.W. *and* VAN OS, G.J. 1962. Community reaction criteria for external noises. N.P.L. Symposium No. 12, 1962, Paper F-5, London, H.M.S.O.

12. DOELLE, L.L. 1965. Acoustics in architectural design. Bibliography No. 29, Ottawa, Division of Building Research, N.R.C., 1965.

13. A consideration of aircraft noise and studio roof insulation. BBC Research Department Report No. B-092, Serial No. 1966/29.

SMW

Printed by BBC Research Department, Kingswood Warren, Tadworth, Surrey